AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 100:225–246 (1996)

Dental Variation Among Four Prehispanic Mexican Populations

REBECA HAYDENBLIT
Department of Biological Anthropology, Hominid Evolutionary Biology Research Group, University of Cambridge, Cambridge CB2 3DZ, United Kingdom

KEY WORDS Mesoamerican Indians, Dental morphological traits, Dental variation

ABSTRACT In this paper, the dental morphology of prehispanic Mesoamerican populations is described, compared, and examined within the context of New World dental variation. Twenty-eight morphological dental traits were studied and compared in four samples of prehispanic Mexican populations. After eliminating intra- and interobserver error, the dental morphological characteristics observed show evidence of heterogeneity among the populations. In particular, the oldest population, Tlatilco (1300–800 BC), was significantly different from the other three groups, Cuicuilco (800–100 BC), Monte Albán (500 BC–700 AD) and Cholula (550–750 AD). When the four samples were compared to other Mongoloid populations, either univariately or multivariately, it was observed that the Mexican groups did not follow a strict Sinodont (characteristic of Northeast Asia)/Sundadont (characteristic of Southeast Asia) classification (Turner [1979] Am. J. Phys. Anthropol. 51:619–636). From the traits examined, 27% presented frequencies consistent with Sinodont variation, while 73% of the traits showed similar incidence to Southeast Asian groups. Multivariately, the Mexican populations were found to fit an overall Sundadont classification. These results indicate that there is more dental morphological variation among American Indian populations than previously shown.

When Columbus reached the American continent in 1492, the American Indian occupation stretched from the Bering Strait to Tierra del Fuego. These native populations had an extraordinary cultural, linguistic, and biological diversity, which has fueled extensive debate on their interrelationships and origins.

It is generally accepted that American Indians came from Asia, via the now submerged Bering land bridge (Beringia) when it was exposed during the last episode of glaciation (Fitzhugh and Chaussonnet, 1988; Guthrie, 1990; Hopkins et al., 1982; West, 1981). However, in the last century, debate about timings of migration, affinities, cultural diversity, linguistic complexity, and biological variation in American Indian populations has been the subject of much controversy (Neel and Thompson, 1978; Szathmary, 1984). The observed diversity has been attributed to multiple independent migrations or to a single ancient migration with extensive in situ radiation (Laughlin, 1988).

Early and more recent investigations have shown that American Indian populations are biologically and culturally more similar to modern populations of Northeast Asia. These findings are based on dental morphological features (Turner, 1971, 1985a,b), genetics (Schanfield, 1992; Szathmary and Ossenberg, 1978; Wallace and Torroni, 1992),

Received September 13, 1994; accepted December 10, 1995.

Address reprint requests to Rebeca Haydenblit at her current address: Department of Anatomy and Embryology/Laboratory of Biological Anthropology, Hebrew University–Hadassah, Medical School, P.O.B. 12272, Jerusalem 91010, Israel.

craniofacial shape (Howells, 1989), linguistics (Greenberg et al., 1986), and archaeological assemblages (Dikov, 1978; West, 1981).

At the present time, most research is focused on the question of the number and timing of migrations. But concomitant with this question, research should also be focused on trying to measure and understand the biological variation among American Indian populations. Two points of view have filled this line of research. One suggests that, given the vast geographic area where American Indian populations have spread, their variation within and between groups is modest. This view is based on studies of the surficial features of the body, like skin color, hair, and epicanthic fold (Stewart, 1973; Stewart and Newman, 1951). The other view defends more variability among American Indian populations, based on osteological and dental features of the body (Comas, 1960; Hrdlička, 1937; Neumann, 1952; Sciulli, 1990).

The study of dental morphological characteristics has been a useful tool for anthropologists. The unique qualities that make teeth valuable for evolutionary studies are well known. Teeth are a well preserved part of the body, and accordingly constitute a large proportion of the human fossil remains. Dental traits have a strong genetic component responsible for their occurrence and expression, are evolutionary conservative to change at species level (Moorrees, 1962; Scott and Turner, 1988), exhibit little to no sexual dimorphism, and are largely independent of one another (Scott and Turner, 1988). Studies on dental morphological traits have provided information regarding population origins (Turner, 1990), affinities and relationships (Brewer-Carias et al., 1976; Turner, 1987), microevolutionary patterns (Turner, 1983), and migration patterns (Greenberg et al., 1986). The dental variability provides information on phylogenic and ontogenic studies for understanding variation within and between species (Birdsell, 1972; Campbell, 1971; Coon, 1962).

Studies of the dental morphology of New World populations have accumulated at a rapid pace. In terms of geographic regions, a large number of dental studies have focused on living populations of the Aleut-Eskimos (Moorrees, 1957; Pedersen, 1949; Turner, 1991), Inuit (Mayhall, 1979), Pima Indians (Dahlberg, 1963; Scott et al., 1983), and Indians of the North American Southwest (Dahlberg, 1963; Turner, 1993). Fewer studies have concentrated on the Central and South American Indians (Baume and Crawford, 1978, 1980; Palomino et al., 1977; Pompa, 1990; Turner 1983, 1986a,b).

Mesoamerica is a geographical natural bottleneck, and, during the initial spread from North to South America, humans have certainly passed through the narrow funnel of Mexico and the Isthmus of Tehuantepec. Mesoamerica is the area defined on the basis of distinctive geographical and cultural traits and patterns shared by Olmecs, Mixtecs, Zapotecs, Maya, Aztecs, and various other civilizations. The boundaries of Mesoamerica undoubtedly shifted at various times in its history (Kirchhoff, 1952). From the time of the Olmecs (2300 BC) to the conquest of the Aztec empire by the Spanish (1521 AD), some of these civilizations overlapped in time and space. The Mesoamerican Indians had distinct cultural (Blanton et al., 1993) and probably biological characteristics (Stewart, 1970), as seen in the archaeological evidence (Heyden and Gendrop, 1988). Little is known about the origins, migrations, and affinities of prehispanic Mesoamerican populations (Culbert, 1978; Porter, 1993). The study of skeletal remains from different Mesoamerican groups should help us to understand these issues. The current literature on the prehispanic Mesoamerican Indians is very large, but this research has been mainly focused towards the archaeological (Byers, 1967; Heyden and Gendrop, 1988), cultural (Blanton et al., 1993; Piña, 1972; Porter, 1993), and physical aspects (Anderson, 1965; Crawford, 1992; Stewart, 1970). Few studies have concentrated on the dental morphological variation of these groups (Pompa, 1990; Turner, 1983, 1986a).

For the present study, observations of 28 morphological dental traits were made on more than 200 prehispanic Mexican Indians. In this paper, I have 1) described the morphological features of permanent teeth of prehispanic Mexican Indians, 2) compared the variability in dental morphology among four prehispanic groups, and 3) analyzed the

TABLE 1. Number of individuals included in each of the skeletal groups studied

Group	Code name[1]	Maxillae	Mandibles	Sample size[2]
Tlatilco	(TLA)	59	39	59
Cuicuilco	(CUI)	47	34	47
Monte Albán	(MA)	68	57	68
Cholula	(CHO)	35	31	35
Total		209	161	209

[1] Code names are used in subsequent tables.
[2] Sample size for the dental morphological traits are given in Tables 3 and 4.

dental morphology of prehispanic Mexican Indians in the broader context of New World dental variation.

MATERIALS AND METHODS

Groups studied

Morphological dental traits were scored on four skeletal groups of prehispanic populations within Mesoamerica. The groups and sample sizes studied are shown in Table 1, and their geographical distribution is illustrated in Figure 1.

Tlatilco. This skeletal series was excavated from burial caves situated in the Valley of Mexico. The archaeological site dates back to the Early Preclassic period of Mesoamerica between 1300 and 800 BC (Porter, 1953; Tolstoy, 1978).

Cuicuilco. This skeletal series was excavated in the Valley of Mexico. It is dated to the Middle Preclassic period between 800 and 100 BC (Semo, 1981; Tolstoy, 1978).

Monte Albán. This archaeological site is located on top of a hill that dominates the Valley of Oaxaca. The skeletal series belongs to the Preclassic and Classic periods of Mesoamerica and it is dated between 500 BC and 700 AD (Blanton et al., 1993; Winter, 1989).

Cholula. This site, containing the largest pyramid in America, is located in the Valley of Puebla. The skeletal group is dated between 550 and 750 AD belonging to the Classic period (Nicholson, 1978).

All the skeletal material is housed in the National Museum of Anthropology and History, Mexico City.

Sample selection was based on preservation of teeth. Only permanent teeth were utilized. Studies to date have indicated that dental traits are nearly free of sex influence (Scott and Turner, 1988). Thus, the individual sex was not considered for this study. Skulls without extensive premortem tooth loss, extreme attrition, or caries were included and scored in this study.

Samples and morphological variables scored

Twenty-eight morphological features of the permanent dentition were assessed as 89 tooth-trait combinations according to the criteria established in the standardized dental plaques from the Arizona State University (ASU) (provided by Christy G. Turner II). This combination of dental traits was used with the criteria that they would encompass as many different teeth as possible and yield a wide range of observations. The morphological dental traits and their scoring classification are summarized in Table 2. For detailed descriptions of each trait, see Turner et al. (1991). The scoring procedure used in this study follows that of Turner and Scott (1977), by which the trait is scored per individual rather than per side or per tooth. In summary, when a trait exhibited presence/absence asymmetry, it was scored as present. When multiple categories were used and asymmetry was present, the highest category was counted. This method not only maximizes sample size but also assumes that the side exhibiting the greatest expression is closest to the true genetic potential for that trait on an individual basis (Turner, 1969). The majority (18 of the traits) were scored using reference plaques of graded variation (Turner et al., 1991). Five of the traits were scored on a discrete (presence or absence) criterion. 5 exceptions that did not follow this scoring procedure were winging (scored as bilateral, unilateral, straight, or counter-winging), interruption groove (scored as absent, present in the mesiolingual, distolingual, both mesio- and distolingual or medial area), groove pattern (scored Y, +, X, [Jorgensen, 1955]), the score of cusp number (which represents the actual number of cusps) and root number (which represents the actual number of roots).

Fig. 1. Map of Mexico showing the location of the archaelogical sites where the skeletal groups used in this study were found.

While variation in trait morphology was scored along a graded scale in each group, trait expression was dichotomized into presence/absence only for the analysis of population affinities. In most cases, any degree of trait development was considered to be a positive expression. One exception to this rule involved hypocone development, in which only full expression (grades 4 and 5) was considered positive.

The sample sizes represent individuals in all the tables related to dental morphological traits.

Dental morphological traits are, for the most part, expressed independently of each other, and only shoveling/double shoveling and Carabelli's trait/protostylid have been shown to be moderately correlated (Scott et al., 1983; Turner, 1987). Because of intertrait correlation, only the key teeth (I^1 for shoveling and M^1 for Carabelli's trait) were included in the statistical analyses of these traits.

Intraobserver variation was assessed by repeated scoring of 40 tooth-trait combinations in a random sample of 50 skulls. Observation sessions were separated by six months, and the methods used in quantifying observer variation were selected from those recommended by Nichol and Turner (1986) as follows. For each morphological trait, three percentages of intraobserver error were calculated: 1) the percentage of cases in which a one-grade scoring difference was assigned for a trait during the first and second sessions (variant scoring %), 2) the percentage of cases in which greater than a one-grade scoring difference was found between the first and second sessions (>1-grade variant scoring %), and 3) the percentage of instances in which a trait was scored present in one session and absent in the other (presence/absence variance %). The mean intraobserver error across 20 maxillary and 20 mandibular dental traits was found to be well within the figures quoted

TABLE 2. Dental morphological traits examined in this study

Trait	Teeth examined[1]	Grades[2]	Grades absent[3]	Expression dichotomy
Winging	UI1		0–3[4]	2/0–3
Labial curve	UI1	0–4		+/–,+
Shoveling	UI1,UI2,UC,LI1	0–7		3–7/0–7
Double shoveling	UI1,UI2,UC	0–6		2–6/0–6
Interruption groove	UI1,UI2		0,M,D,MD,MED[5]	+/–,+
Tuberculum dentale	UI1,UI2,UC	0–9		1–9/0–9
Mesial ridge	UC	0–3		1–3/0–3
Distal accessory ridge	UC,LC	0–5		2–5/0–5
Accessory cusps	UP1,UP2		0–1	+/–,+
Uto-Aztec	UP1		0–1	+/–,+
Metacone	UM1,UM2,UM3	0–5		4–5/0–5
Hypocone	UM1,UM2,UM3	0–5		2–5/0–5
Metaconule (cusp 5)	UM1,UM2,UM3	0–5		1–5/0–5
Carabelli's trait	UM1,UM2,UM3	0–7		2–7/0–7
Parastyle	UM1,UM2,UM3	0–5		1–5/0–5
Enamel extensions	UP1,UP2,UM1,UM2,UM3,LP1,	0–3		2–3/0–3
	LP2,LM1,LM2,LM3	0–3		2–3/0–3
Root number	LC,UP1,UP2,LP1,LP2,UM1,		0–3[6]	2,1/1–3
	UM2,UM3,LM1,LM2,LM3			3,1/1–4
Peg/reduced/congenital absence	UI2,UM3		0–1	+/–,+
Odontome	UP1,UP2,LP1,LP2		0–1	+/–,+
Congenital absence	UP2,LI1,LP2,LM3		0–1	+/–,+
Lingual cusp variation	LP1,LP2	0–9		2–9/0–9
Groove pattern	LM1,LM2,LM3		Y,+,X[7]	Y/Y,+,X
Cusp number	LM1,LM2,LM3		4–6[6]	4–6/4–6
Deflecting wrinkle	LM1,LM2,LM3	0–3		3/0–3
Protostylid	LM1,LM2,LM3	0–8		1–8/0–8
Hypoconulid (cusp 5)	LM1,LM2,LM3	0–5		4–5/0–5
Entoconulid (cusp 6)	LM1,LM2,LM3	0–6		6/4–6
Metaconulid (cusp 7)	LM1,LM2,LM3	0–5		1–5/0–5

[1] U, upper jaw. L, lower jaw.
[2] The number of grades on the reference plaque and expression dichotomy from Turner et al. (1991).
[3] Grade absent = The grades representing absence for the trait when analyzed on a presence/absence basis.
[4] Bilateral winging (0), unilateral winging (1), straight (2), and counter-winging (3).
[5] Absent (0), present in the mesiolingual (M), distolingual (D), both mesio- and distolingual (MD), or medial area (MED) (Turner, 1991).
[6] Number of roots or cusps.
[7] Classification system developed by Jorgensen (1955).

by Nichol and Turner (1986). The means for these measures of intraobserver error for the maxillary teeth were 28.9%, 5.4%, and 14.4%, respectively; for the mandibular teeth the means were 20.4%, 4.7%, and 6.3%, respectively.

Interobserver concordance was calculated by comparing the results obtained by Prof. C.G. Turner II and the author on the same series of 143 skulls from Burma (housed at the Natural History Museum, London, and the Duckworth Collection, Cambridge). The comparison used individual data provided by Prof. Turner for this purpose. A total of 47 traits were examined and compared (see Appendix). Methods used for calculating interobserver concordance between the two observers followed those of Nichol and Turner (1986). For each morphological trait, three values were calculated to assess interobserver concordance in scoring the sample: 1) the >1-grade variant-scoring percentage, 2) the average difference expressed in percentage of a grade made for the average individual scored, taking into account the directionality of the difference (net mean grade difference %), and 3) the paired-sample t test. The results of the analysis of interobserver concordance are presented in the Appendix. These values were calculated as >10% for the >1-grade variant-scoring % and >5% for the net mean grade difference % and the paired-sample t test exceeding the 0.05 probability level (Nichol and Turner, 1986). Only those dental traits exceeding the critical levels for two of these values were considered to be unreliable for interobserver comparisons. Using this criteria, 14 traits were rejected for interobserver concordance. These are double shovel on the maxillary first premolar, interruption groove on the maxillary lateral incisor, tuberculum den-

tale on the maxillary central and lateral incisor and canine, distal accessory ridge on the maxillary canine, accessory cusps on the maxillary first premolar, enamel extension on the maxillary first molar, lingual cusp number on the mandibular second premolar, groove pattern on the mandibular first and second molars, cusp number and deflecting wrinkle on the mandibular second molar, and cusp 5 (hypoconulid) on the mandibular first molar. These traits were not used in the statistical analysis when comparing the Mexican samples to other populations from the New World. Of the 14 traits that produced high interobserver variance, 7 traits were rejected also by Nichol and Turner (1986). In both studies the following traits were rejected: the interruption groove on the maxillary lateral incisor, the tuberculum dentale on the maxillary central and lateral incisors and canine, the maxillary canine distal accessory ridge, the accessory cusps on the maxillary first premolar, and the groove pattern of the mandibular second molar.

Chi-square statistics using Bonferroni's corrected levels of significance (Miller, 1981) were calculated to detect significant differences in specific trait frequencies between groups. Mean measure of divergence (Green and Suchey, 1976) was used for distance statistics. Statistical tests were performed using SPSS/PC+ and SPSS for Windows.

RESULTS

Dental morphology of prehispanic Mesoamerican populations

To study the variation in dental morphology among prehispanic Mesoamerican populations, 28 dental morphological variables (observed on 89 tooth-trait combinations) were scored (Table 2). Tables 3 and 4 show the frequency distribution and sample size (n = number of individuals) for trait combinations that showed the strongest differences among the groups for the maxilla and the mandible of the four Mesoamerican populations studied (data of the frequencies and sample size of each tooth-trait combination are available upon request). The most salient features of dental variability among these groups are summarized below.

For traits of the maxillary dentition (Table 3):

1. Maxillary anterior teeth of Mesoamerican Indians exhibit a high frequency of straight winging (81.0%), in this case defined as both maxillary central incisors forming a straight labial surface and following the curvature of the dental arch. Both maxillary incisors exhibit light but consistent lingual shoveling, and shoveling of the canine is uncommon (1.5%). Within the groups, double shoveling is frequent but not very pronounced on both incisors, and on the canine is not common (9.0%). This trait on the canine is completely absent in Tlatilco and pronounced only in a low percentage (3.3%) in Cuicuilco. Interruption groove on the I^1 is observed in both extremes: it is not expressed at all in 56.7% of all the groups, and at the same time is common on both the mesiolingual and distolingual borders on 41.2% among all the groups. This trait follows a different pattern on the I^2, where the trait is expressed in a smaller percentage (10.6%) on the mesiolingual border and expressed in both the mesiolingual and distolingual borders (63.5%). The tuberculum dentale on the I^2 is very variable in its shape, from weak (21.3%) to pronounced (50.0%), and is completely absent in 28.7% among all the groups. This trait is uncommon on the canine (15.2%). Peg, reduced, and congenital absence of the I^2 is uncommon among the groups (2.8%) and is absent in Cuicuilco.

2. Odontomes are very uncommon in the maxillary premolar teeth; only Monte Albán shows a frequency of 3.8% in the first premolar. The Uto-Aztec premolar is very rarely seen, and again only a 2.0% frequency was observed in Monte Albán (Table 3).

3. On the maxillary molars (Table 3), the hypocone cusp development can be observed from moderate to very large size on the M^1. This cusp experiences more frequent and more severe reduction on the M^2 and especially on the M^3 among the groups. The metaconule is present at a low frequency on the first (4.1%), second (6.1%), and third (11.5%) molars, and in Cuicuilco this trait is completely absent. Carabelli's trait, while relatively uncommon, is expressed primarily as slight to moderate forms and is seen rarely

as tubercules on the first molars of all the groups (0.7%). Parastyle is rare in all the groups, and only Tlatilco has a 2.7% presence of the trait on the second molars. Enamel extension is common, and is expressed from a faint to a moderate degree. Peg, reduced, and congenital absence of the M^3 is not very common (15.4%).

For traits of the mandibular dentition (Table 4):

1. Shoveling of the mandibular central incisors has a low to intermediate frequency, and expression is rarely very pronounced (1.6%). The distal accessory ridge is common among all the groups, but its degree of development is weak (Table 4).
2. Multiple lingual cusps are very uncommon on both the first (3.8%) and second (7.1%) premolars in all the groups. Odontomes are rare and only present in Monte Albán on the second premolar (1.7%). Congenital absence of the P_2 is very rare and is only seen in Monte Albán (1.5%).
3. Within all the groups, the vast majority of the first molars retains a groove configuration of the "Y" type (78.6%), but the "+" pattern is predominant in the second molars (91.7%) (Table 4). In the third molars the groove varies from "+" to "X" pattern. On the M_2 of Cholula, the "+" is completely predominant. Among the groups, the deflecting wrinkle is infrequent in the first (4.2%) and second molars (5.5%) and is completely absent in Cuicuilco. The protostylid is also very rare. Tlatilco shows a frequency of 2.1% on the first molars and Monte Albán 2.0% on the second molars. The hypoconulid is moderately common and varies in size in all the molars. The presence of the entoconulid on the mandibular molars is not very common (7.0% on the first molars), and the metaconulid is present only on the third molar (2.2%) among all the groups. Both mandibular first and second molars have a high frequency of two roots. Congenital absence of the M_3 is present in 11.7% between the groups (Table 4).

The morphology of the permanent teeth from Tlatilco, Cuicuilco, Monte Albán, and Cholula may be summarized as follows:

1. All the populations are characterized by straight winging and lightly but consistently sculpted maxillary anterior teeth.
2. These populations are characterized by having conservative maxillary molars, which feature full development of the hypocone on the M^1. The degree of development of this cusp gets weaker in the other maxillary molars. The metaconule, Carabelli's cusp, and parastyle are not common.
3. Both maxillary and mandibular premolars exhibit a very conservative shape.
4. On the mandibular molars, the "Y" groove pattern is frequent in the M_1, but the "+" pattern predominates in the M_2. Molar cusp number on all the populations exhibit a 5-4-4 dental pattern, and accessory cusps are not very common.

Differences of the dental morphology between Tlatilco, Cuicuilco, Monte Albán, and Cholula

The between-group analysis of dental morphological variation centers primarily on one question: Is there a difference in the degree of divergence among the Mesoamerican groups?

In order to address this question, the method employed was the mean measure of divergence (MMD) (Berry and Berry, 1967). Trait frequencies based either upon presence/absence dichotomization or grades were transformed according to the Freeman-Tukey transformation recommended by Green and Suchey (1976). The MMD values for the four Mesoamerican populations are present in Table 5. Two points are apparent. First, the MMD values among Cuicuilco, Monte Albán, and Cholula are very small, thus corresponding to the lack of significant differences among these groups. The mean of the MMD values among these three groups is 0.001. Second, the MMD values are consistently larger for Tlatilco. There are markedly divergent MMD values for the three groups (Cuicuilco, Monte Albán, and Cholula) when compared with the Tlatilco group. These results show that Tlatilco is the most divergent group from all other Mesoamerican groups. Cuicuilco and Cholula are most closely related, while Cuicuilco and Monte Albán are next closest in relationship. Similar results were obtained when I

TABLE 3. Maxillary crown frequencies (by grade) of prehispanic Mesoamerican Indians

Trait/tooth	Population	n[1]	Grade 0	1	2	3	4	5	6	7
Winging I1[2]										
	TLA	28	10.7	7.1	**78.6**	3.6				
	CUI	17	11.8	0.0	**88.2**	0.0				
	MA	20	20.0	5.0	**75.0**	0.0				
	CHO	19	15.8	0.0	**84.2**	0.0				
Shoveling I1										
	TLA	31	6.5	12.9	**45.2**	16.1	9.7	3.2	6.5	
	CUI	18	5.6	**27.8**	16.7	16.7	22.2	5.6	5.6	
	MA	26	3.8	7.7	30.8	19.2	**34.6**	0.0	3.8	
	CHO	22	13.6	9.1	9.1	**36.4**	18.2	9.1	4.5	
Shoveling I2										
	TLA	29	3.4	13.8	**31.0**	13.8	13.8	17.2	6.9	0.0
	CUI	19	10.5	10.5	21.1	**26.3**	10.5	15.8	5.3	0.0
	MA	30	16.7	10.0	16.7	20.0	**23.3**	13.3	0.0	0.0
	CHO	22	4.5	22.7	9.1	**36.4**	4.5	13.6	4.5	4.5
Shoveling C										
	TLA	33	**97.0**	3.0						
	CUI	30	**100.0**	0.0						
	MA	43	**97.7**	2.3						
	CHO	27	**100.0**	0.0						
Double shoveling I1										
	TLA	30	30.0	**33.3**	20.0	3.3	13.3	0.0	0.0	
	CUI	19	15.8	**26.3**	15.8	21.1	10.5	5.3	5.3	
	MA	25	16.0	20.0	**32.0**	12.0	8.0	12.0	0.0	
	CHO	23	13.0	8.7	**39.1**	4.3	13.0	21.7	0.0	
Double shoveling I2										
	TLA	28	**53.6**	28.6	14.3	3.6	0.0			
	CUI	23	**39.1**	30.4	26.1	0.0	4.3			
	MA	34	**44.1**	38.2	17.6	0.0	0.0			
	CHO	24	**41.7**	20.8	37.5	0.0	0.0			
Double shoveling C										
	TLA	33	**100.0**	0.0	0.0	0.0				
	CUI	30	**90.0**	0.0	6.7	3.3				
	MA	43	**90.7**	4.7	4.7	0.0				
	CHO	27	**81.5**	0.0	18.5	0.0				
Interruption groove I1[3]										
	TLA	30	**70.0**	0.0	3.3	26.7	0.0			
	CUI	18	**55.6**	0.0	0.0	44.4	0.0			
	MA	26	46.2	0.0	0.0	**53.8**	0.0			
	CHO	24	**52.2**	4.3	0.0	43.4	0.0			
Interruption groove I2[3]										
	TLA	24	25.0	25.0	4.2	**45.8**	0.0			
	CUI	22	13.6	13.6	0.0	**72.7**	0.0			
	MA	33	24.2	3.0	0.0	**72.7**	0.0			
	CHO	26	26.9	11.5	0.0	**57.7**	3.8			
Tuberculum dentale I2										
	TLA	28	21.4	3.6	0.0	10.7	**53.6**	7.1	3.6	
	CUI	23	21.7	17.4	0.0	**30.4**	26.1	4.3	0.0	
	MA	33	**33.3**	12.1	3.0	0.0	27.3	18.2	6.1	
	CHO	24	**37.5**	4.2	0.0	8.3	25.0	25.0	0.0	
Tuberculum dentale C										
	TLA	32	**96.9**	0.0	0.0	0.0	3.1	0.0	0.0	
	CUI	29	**89.7**	0.0	0.0	0.0	3.4	6.9	0.0	
	MA	44	**72.7**	2.3	0.0	4.5	2.3	13.6	4.5	
	CHO	27	**85.2**	0.0	3.7	0.0	0.0	11.1	0.0	
Peg/reduced/ congenital absence I2[4]										
	TLA	34	**97.1**	2.9						
	CUI	28	**100.0**	0.0						
	MA	50	**96.0**	4.0						
	CHO	30	**96.7**	3.3						
Uto-Aztec P1[4]										
	TLA	35	**100.0**	0.0						
	CUI	34	**100.0**	0.0						
	MA	51	**98.0**	2.0						
	CHO	29	**100.0**	0.0						

(continued)

TABLE 3. Maxillary crown frequencies (by grade) of prehispanic Mesoamerican Indians (Continued)

			Grade							
Trait/tooth	Population	n[1]	0	1	2	3	4	5	6	7
Odontome P1[4]										
	TLA	36	**100.0**	0.0						
	CUI	33	**100.0**	0.0						
	MA	52	**96.2**	3.8						
	CHO	29	**100.0**	0.0						
Odontome P2[4]										
	TLA	35	**100.0**							
	CUI	36	**100.0**							
	MA	38	**100.0**							
	CHO	34	**100.0**							
Hypocone M2										
	TLA	35	14.3	8.6	5.7	20.0	**25.7**	**25.7**		
	CUI	32	3.1	9.4	**71.9**	6.3	6.3	3.1		
	MA	48	4.2	12.5	**47.9**	12.5	12.5	10.4		
	CHO	25	0.0	4.0	**44.0**	8.0	24.0	20.0		
Cusp 5 M1										
	TLA	34	**91.2**	0.0	0.0	2.9	5.9			
	CUI	32	**100.0**	0.0	0.0	0.0	0.0			
	MA	55	**94.5**	1.8	3.6	0.0	0.0			
	CHO	25	**100.0**	0.0	0.0	0.0	0.0			
Cusp 5 M2										
	TLA	37	**83.8**	5.4	5.4	0.0	5.4	0.0		
	CUI	31	**100.0**	0.0	0.0	0.0	0.0	0.0		
	MA	52	**96.2**	1.9	0.0	0.0	1.9	0.0		
	CHO	27	**96.3**	0.0	0.0	0.0	0.0	3.7		
Cusp 5 M3										
	TLA	28	**75.0**	3.6	0.0	10.7	7.1	3.6		
	CUI	19	**100.0**	0.0	0.0	0.0	0.0	0.0		
	MA	21	**90.5**	0.0	0.0	9.5	0.0	0.0		
	CHO	19	**94.7**	0.0	5.3	0.0	0.0	0.0		
Carabelli M1										
	TLA	34	**79.4**	14.7	2.9	0.0	0.0	0.0	2.9	
	CUI	30	**93.3**	3.3	3.3	0.0	0.0	0.0	0.0	
	MA	55	**65.5**	9.1	7.3	10.9	3.6	3.6	0.0	
	CHO	25	**72.0**	8.0	20.0	0.0	0.0	0.0	0.0	
Parastyle M1										
	TLA	34	**100.0**							
	CUI	32	**100.0**							
	MA	55	**100.0**							
	CHO	25	**100.0**							
Parastyle M2										
	TLA	37	**97.3**	0.0	0.0	0.0	0.0	2.7		
	CUI	31	**100.0**	0.0	0.0	0.0	0.0	0.0		
	MA	52	**100.0**	0.0	0.0	0.0	0.0	0.0		
	CHO	27	**100.0**	0.0	0.0	0.0	0.0	0.0		
Enamel extension M1										
	TLA	32	**40.6**	37.5	15.6	6.3				
	CUI	31	**35.5**	25.8	22.6	16.1				
	MA	40	27.5	2.5	10.0	**60.0**				
	CHO	21	33.3	14.3	4.8	**47.6**				
Peg/reduced/ congenital absence M3[4]										
	TLA	32	**96.9**	3.1						
	CUI	30	**83.3**	16.7						
	MA	41	**80.5**	19.5						
	CHO	27	**77.8**	22.2						

[1] Sample size refers to the number of individuals.
[2] Bilateral winging (0), unilateral winging (1), straight (2), and counter-winging (3).
[3] Absent (0), present in the mesiolingual (1), distolingual (2), both mesio- and distolingual (3), or medial area (4).
[4] Absent (0), present (1).
Numbers in bold are the highest frequencies.

TABLE 4. Mandibular crown frequencies (by grade) of prehispanic Mesoamerican Indians

			Grade					
Trait/tooth	Population	n[1]	0	1	2	3	4	5
Shoveling I1								
	TLA	35	**88.6**	11.4	0.0	0.0		
	CUI	28	**60.7**	28.6	3.6	7.1		
	MA	34	**52.9**	38.2	8.8	0.0		
	CHO	28	32.1	**60.7**	7.1	0.0		
Distal accessory ridge C								
	TLA	45	**37.8**	33.3	26.7	2.2	0.0	
	CUI	45	**55.6**	20.0	15.6	6.7	2.2	
	MA	59	**39.0**	28.8	23.7	6.8	1.7	
	CHO	34	23.5	**52.9**	17.6	5.9	0.0	
Lingual cusp variation P1								
	TLA	47	**95.7**	4.3	0.0	0.0		
	CUI	45	**93.3**	0.0	4.4	2.2		
	MA	61	**98.4**	0.0	1.6	0.0		
	CHO	32	**96.9**	0.0	3.1	0.0		
Lingual cusp variation P2								
	TLA	47	**93.6**	4.3	2.1	0.0		
	CUI	45	**97.8**	0.0	2.2	0.0		
	MA	59	**88.1**	0.0	6.8	5.1		
	CHO	31	**93.5**	0.0	6.5	0.0		
Odontome P1[2]								
	TLA	47	**100.0**					
	CUI	45	**100.0**					
	MA	62	**100.0**					
	CHO	33	**100.0**					
Odontome P2[2]								
	TLA	47	**100.0**	0.0				
	CUI	46	**100.0**	0.0				
	MA	60	**98.3**	1.7				
	CHO	32	**100.0**	0.0				
Congenital absence P2[2]								
	TLA	47	**100.0**	0.0				
	CUI	46	**100.0**	0.0				
	MA	66	**98.5**	1.5				
	CHO	33	**100.0**	0.0				
Groove pattern M1[3]								
	TLA	37		**73.0**	27.0	0.0		
	CUI	27		**74.1**	25.9	0.0		
	MA	41		**82.9**	17.1	0.0		
	CHO	26		**84.6**	15.4	0.0		
Groove pattern M2[3]								
	TLA	40		17.5	**82.5**	0.0		
	CUI	36		5.6	**88.9**	5.6		
	MA	51		2,0	**96.1**	2.0		
	CHO	29		0.0	**100.0**	0.0		
Deflecting wrinkle M1								
	TLA	49	**98.0**	0.0	2.0	0.0		
	CUI	44	**100.0**	0.0	0.0	0.0		
	MA	61	**90.2**	6.6	0.0	3.3		
	CHO	35	**97.1**	0.0	2.9	0.0		
Deflecting wrinkle M2								
	TLA	46	**97.8**	2.2				
	CUI	41	**100.0**	0.0				
	MA	61	**86.9**	13.1				
	CHO	33	**97.0**	3.0				
Protostylid M1								
	TLA	48	**97.9**	2.1				
	CUI	45	**100.0**	0.0				
	MA	61	**100.0**	0.0				
	CHO	35	**100.0**	0.0				

(continued)

TABLE 4. Mandibular crown frequencies (by grade) of prehispanic Mesoamerican Indians (Continued)

Trait/tooth	Population	n[1]	Grade 0	1	2	3	4	5
Protostylid M2								
	TLA	45	**100.0**	0.0				
	CUI	41	**100.0**	0.0				
	MA	61	**98.4**	1.6				
	CHO	33	**100.0**	0.0				
Cusp 5 M2								
	TLA	46	**43.5**	0.0	6.5	13.0	21.7	15.2
	CUI	40	**67.5**	0.0	2.5	2.5	25.0	2.5
	MA	59	**83.1**	0.0	1.7	3.4	6.8	5.1
	CHO	32	**65.6**	0.0	0.0	6.3	21.9	6.3
Cusp 6 M1								
	TLA	49	**93.8**	0.0	2.1	4.2	0.0	0.0
	CUI	42	**95.2**	0.0	0.0	0.0	2.4	2.4
	MA	60	**91.7**	0.0	0.0	6.7	1.7	0.0
	CHO	34	**91.2**	0.0	0.0	0.0	2.9	5.9
Cusp 7 M3								
	TLA	37	**97.3**	0.0	0.0	2.7	0.0	
	CUI	32	**93.8**	0.0	0.0	0.0	6.3	
	MA	45	**93.8**	0.0	0.0	0.0	6.3	
	CHO	22	**100.0**	0.0	0.0	0.0	0.0	
Congenital absence M3[2]								
	TLA	40	**100.0**	0.0				
	CUI	39	**85.7**	14.3				
	MA	56	**87.5**	12.5				
	CHO	28	**85.7**	14.3				

[1] Sample size refers to the number of individuals.
[2] Groove pattern = Y (1), + (2), X (3).
[3] Absent (0), present (1).
Numbers in bold are highest in frequencies.

TABLE 5. Mean measures of divergence among Mesoamerican populations[1]

	TLA	MA	CUI	CHO
TLA	—			
MA	0.074	—		
CUI	0.054	0.020	—	
CHO	0.072	−0.012	−0.005	—

[1] Trait frequencies scored by presence/absence dichotomy. $\bar{x}$MMD = 0.001 (minus TLA), 0.033 (with TLA).

performed the MMD values scoring trait frequencies by grades instead of presence/absence. Thus, two noteworthy points emerged from this between-group analysis: first, Tlatilco is the most distant group among the Mesoamerican populations, and, second, Cuicuilco, Monte Albán, and Cholula are closely related.

To detect significant differences in specific trait frequencies between the different Mesoamerican groups, chi-square statistics were calculated. The chi-square tests revealed that 21 (25%) of the 85 tooth-trait combinations studied exhibit significant differences among the four groups ($P = <0.05$). Because there is always a risk of a type I error, Bonferroni's correction was applied (Miller, 1981). Chi-square tests showed that in only four (4.70%) of the 85 tooth-trait combinations were there significant differences between observed and expected observations among the four populations ($P = <0.0005$) (Table 6). These traits are enamel extension on the second and third maxillary molars and enamel extension on the first and second mandibular molars. Enamel extension on both maxillary second and third molars is very variable among the groups. Expression of this trait varies in length from short to long. On the second molars, a longer extension is seen in Monte Albán, and on the third molars Cholula has the highest extension. A similar pattern is present on both mandibular first and second molars; a lengthy extension is seen in Cuicuilco, Monte Albán, and Cholula but not in Tlatilco, where the extension is minimal.

To further test whether the number of significant differences obtained were not expected by chance alone, each population was considered as a group against the other three populations grouped together (e.g., TLA vs.

TABLE 6. Summary of chi-square analysis of dental morphological trait variation in Mesoamerican groups

Group[1]	Number of significant differences[2]	Traits showing significance
MES	4/85 (5%)	Enamel extension M^2, M^3, M_1, M_2
TLA	5/85 (6%)	Enamel extension M^1, M^2, M_1, M_2 Groove pattern M_3
MA	1/85 (2%)	Enamel extension M^1
CUI	0/85 (0%)	
CHO	0/85 (0%)	

[1] MES = TLA, CUI, MA, and CHO; TLA = TLA vs. CUI/MA/CHO; MA = MA vs. TLA/CUI/CHO; CUI = CUI vs. TLA/MA/CHO; CHO = CHO vs. TLA/CUI/MA.
[2] Using Bonferroni's correction (P = <0.0005).

TABLE 7. Logistic regression analysis of dental morphological traits between Tlatilco and CUI/MA/CHO

a. Using five dental traits[1]

Trait	Wald	df	P^2
Enamel extension M^1	1.333	1	n.s.
Enamel extension M^2	6.314	1	<0.0005
Enamel extension M_1	4.579	1	<0.0005
Enamel extension M_2	0.072	1	n.s.
Groove pattern M_3	2.469	1	n.s.

b. Using the two most significant traits (enamel extension M^2 and M_1)
Classification:
Maximum classification achieved: 92.3%

	Predicted groups	
Actual group	1	2
CUI/MA/CHO	50	3
TLA	3	22

[1] Traits significantly different between Tlatilco and CUI/MA/CHO.
[2] Using Bonferroni's level of significance. n.s., not significant.

CUI/MA/CHO = Cuicuilco, Monte Albán, and Cholula). The results are summarized in Table 6. Tlatilco differs from the other populations in five traits: enamel extension of the maxillary first and second molars, enamel extension of the mandibular first and second molars, and groove pattern of the maxillary third molar. Two of these, enamel extension of the mandibular molars, also differed significantly among the four Mesoamerican populations. From the other groups, only Monte Albán showed a significant difference for one trait (Table 6). These results suggest that Tlatilco, the oldest population (by a difference of 500 hundred years from the group CUI/MA/CHO), differs in dental morphology from the other Mesoamerican populations studied.

Logistic regression analysis was used to determine which of the five traits discriminate between Tlatilco and CUI/MA/CHO. The results of this analysis show that the discrimination is explained by enamel extension of the maxillary second molar and the mandibular first molar (Table 7a). By using these two variables, 92% of the individuals were correctly attributed to the two groupings (Table 7b).

In summary, two traits, enamel extension of the maxillary second molar and mandibular first molar, are the best discriminators in dental morphology between Tlatilco and CUI/MA/CHO.

Tlatilco, the oldest and the most different population

If the morphological dental traits are considered as 28 traits rather than individual tooth-trait combinations, five traits exhibit higher frequencies in Tlatilco, thirteen are higher in CUI/MA/CHO, and nine show no difference between the two groups (root number was not calculated due to small sample size) (Table 8). Eight traits display marked and systematic differences. Viewed by tooth region, three differences occur in the maxillary incisors (shoveling, double shoveling, and interruption groove), three occur in the maxillary molars (metacone, metaconule, and enamel extension), and two occur in the mandibular molars (cusp number and enamel extension). The frequency of seven traits (shoveling, double shoveling, interruption groove, metacone, enamel extension on maxillary and mandibular molars, and cusp number) is lower in Tlatilco than in the other groups, and one trait (metaconule) is higher in Tlatilco. This observation of increasing morphological expression in conjunction with a morphological complexity through time (Fig. 2) is important for understanding Mesoamerican dental morphological variation.

Considering tooth-trait combinations, such dental traits as double shoveling–UI1, hypocone-UM2, enamel extension–UM3, "Y" groove pattern–LM2, 4 cusp–LM2, and 1 root–LM2, suggests a temporal cline from Tlatilco to Cuicuilco, Monte Albán, and Cholula (Fig. 2A,B). There are 22 dental traits (24.7%) that show a temporal cline from Tlatilco to the other Mesoamerican popula-

tions. In 14 of these (15.7%), the frequencies tend to increase from Tlatilco to the other populations, and in eight traits (9.0%) the frequencies decrease with time.

In conclusion, the between-group analyses of the prehispanic Mexican populations showed that Tlatilco is the most distant group and has a different dental morphology from the other groups.

Comparison of the dental morphology of Mesoamerican and New World populations

In order to place the prehispanic Mexican populations in regional perspective, the dental trait frequencies of Mesoamerican populations were compared with other populations of the New World. Trait selection was based on availability of published data. Population selection was based on published studies using the same methodology (ASU dental plaques) for scoring dental morphology (Turner et al., 1991). I should also emphasize that in selecting the populations not only was the same methodology taken into account, but also the same expression dichotomy taken for each trait.

Data on 15 morphological dental traits were collected and compared among 14 New World populations. The list of dental traits and populations used are shown in Table 9. Of these 15 dental traits, the frequencies of 9 traits in the prehispanic Mexican Indians fall within the range of New World populations. The traits that show a different incidence in the Mesoamerican populations from other American Indians are low frequency of shoveling, protostylid, entoconulid, metaconulid, 3-root in the mandibular M_1, and high frequency of 3-root in the maxillary M^2 (except Tlatilco). These results suggest that although prehispanic Mexican populations and other New World populations are similar, there are some dental morphological differences among them.

Turner has examined the dental morphology of many groups. His research on the dentition of Pacific rim populations has led him to postulate that there are two basic Asian populations, a southern (Sundadont) population and a northern (Sinodont) population (Turner, 1979, 1985b, 1987, 1990). It should be pointed out that the Sinodont/Sundadont classification is largely defined on the basis of a few dental traits. Eight key morphological traits distinguish these two patterns: shoveling and double shoveling of maxillary incisors, enamel extension of maxillary first molars, root number of maxillary second premolars, peg/reduced/congenital absence of maxillary third molars, deflecting wrinkle and root number of mandibular first molars, and groove pattern of mandibular second molars. The Sinodont pattern exhibits these traits more intensively, whereas the Sundadont pattern exhibits simplification of these features.

To further place the prehispanic Mexican Indian trait frequencies in a broader evolutionary context with New World and Asian populations, a discriminant analysis was performed using the Mexican data from this study and data published by Turner on Asian and American Indian populations (Turner, 1983, 1986a, 1987). The discriminant analysis examines whether it is possible to classify a number of cases into specified groups (in this case Sinodont and Sundadont) on the basis of a group of independent variables (the dental trait frequencies) and calculates how this classification compares with the actual group (Sinodont/Sundadont) each population belongs to. Therefore, this analysis had three aims: first, to assess whether it was possible to derive a discriminant function that separates Sundadont and Sinodont populations from Turner's data; second, to assess which dental traits contribute most to this separation; and third, to use the discriminant function derived from Turner's data to determine to which group (Sinodont/ Sundadont) the prehispanic Mexican samples can be statistically allocated. Table 10 shows the list of populations and dental morphological traits used in the discriminant analysis. Because this analysis automatically removes all cases with missing values in any of the variables, only 16 dental morphological traits were used (Table 10b). The results of the first discriminant analysis show that the distribution of Turner's Mongoloid populations can be correctly predicted on the basis of dental morphological traits with 100% accuracy (Table 11a). In other words, the following populations were classified in the Sinodont pattern: Amur, Archaic

TABLE 8. Frequencies and chi-square comparison between Tlatilco and CUI/MA/CHO

		Tlatilco		CUI/MA/CHO		Tlatilco-CUI/MA/CHO	
Dental trait	Tooth	n	frequency	n	frequency	χ^2	P^1
Winging	UI1	28	7	56	16	6.665	n.s.
Labial curve	UI1	31	61	67	73	4.514	n.s.
Shoveling	UI1	31	35	66	59	8.483	n.s.
Shoveling	LI1	27	0	66	1	8.077	<0.05
Double shoveling	UI1	30	17	67	37	11.611	n.s.
Double shoveling	UI2	28	18	81	27	5.126	n.s.
Double shoveling	UC	33	0	100	10	4.352	n.s.
Interruption groove	UI1	30	30	68	50	6.753	n.s.
Interruption groove	UI2	24	75	81	78	9.169	n.s.
Tuberculum dentale	UI1	30	40	66	49	5.569	n.s.
Tuberculum dentale	UI2	28	79	80	69	8.342	n.s.
Tuberculum dentale	UC	32	3	100	19	6.295	n.s.
Mesial ridge	UC	32	3	101	5	2.012	n.s.
Distal accessory ridge	UC	32	3	101	16	4.297	n.s.
Distal accessory ridge	LC	32	31	108	29	1.437	n.s.
Accessory cusps	UP1	37	0	114	0	na	—
Accessory cusps	UP2	38	0	109	0	na	—
Uto-Aztec	UP1	35	0	114	0	0.309	n.s.
Metacone	UM1	34	62	112	84	7.660	<0.01
Metacone	UM2	37	59	110	74	3.044	n.s.
Metacone	UM3	28	32	55	55	6.762	n.s.
Hypocone	UM1	32	44	91	56	14.095	<0.01
Hypocone	UM2	35	26	105	10	19.198	<0.001
Hypocone	UM3	27	7	57	0	6.986	n.s.
Metaconule	UM1	34	9	112	3	7.163	n.s.
Metaconule	UM2	37	16	110	3	12.305	<0.05
Metaconule	UM3	28	25	59	5	11.526	<0.05
Carabelli's trait	UM1	34	6	110	18	9.282	n.s.
Parastyle	UM1	34	0	112	0	na	—
Parastyle	UM2	37	3	110	0	2.993	n.s.
Parastyle	UM3	28	0	57	5	1.527	n.s.
Enamel extension	UP1	30	3	85	0	2.858	n.s.
Enamel extension	UP2	30	7	83	0	5.633	<0.05
Enamel extension	UM1	32	22	92	55	17.412	<0.0005[2]
Enamel extension	UM2	35	31	92	79	29.034	<0.0005[2]
Enamel extension	UM3	25	16	50	62	15.257	<0.001
Enamel extension	LP1	20	5	80	3	0.343	n.s.
Enamel extension	LP2	19	5	78	3	0.371	n.s.
Enamel extension	LM1	33	12	91	44	18.283	<0.0005[2]
Enamel extension	LM2	30	27	85	61	15.385	<0.0005[2]
Enamel extension	LM3	25	12	59	41	8.203	<0.05
Root number	LC	7	0	76	0	na	—
Root number	LP1	6	33	46	17	na	—
Root number	LP2	5	0	36	6	na	—
Root number	LM1	2	0	27	100	na	—
Root number	LM2	3	33	40	98	na	—
Root number	LM3	1	0	34	21	na	—
Peg/reduced/congenital absence	UI2	34	3	108	3	0.002	n.s.
Peg/reduced/congenital absence	UM3	32	3	98	19	4.901	<0.05
Odontome	UP1	36	0	114	2	na	—
Odontome	UP2	35	0	108	0	na	—
Odontome	LP1	31	0	114	0	0.276	n.s.
Odontome	LP2	31	0	113	1	na	—
Congenital absence	UP2	35	0	117	0	na	—
Congenital absence	LI1	30	0	108	0	0.279	n.s.
Congenital absence	LP2	31	0	119	0	0.262	n.s.
Congenital absence	LM3	29	0	97	13	4.333	<0.05
Lingual cusp variation	LP1	31	0	114	3	8.207	<0.05
Lingual cusp variation	LP2	31	0	112	8	9.723	<0.05
Groove pattern	LM1	28	75	75	77	0.062	n.s.
Groove pattern	LM2	28	21	95	4	9.248	<0.01
Groove pattern	LM3	26	19	70	1	21.804	<0.0005[2]
Cusp number	LM1	35	8	104	8	0.155	n.s.
Cusp number	LM2	32	38	107	76	16.421	<0.001
Cusp number	LM3	28	50	80	71	5.032	n.s.

(continued)

TABLE 8. Frequencies and chi-square comparison between Tlatilco and CUI/MA/CHO (Continued)

		Tlatilco		CUI/MA/CHO		Tlatilco-CUI/MA/CHO	
Dental trait	Tooth	n	frequency	n	frequency	χ^2	P^1
Deflecting wrinkle	LM1	35	0	112	2	2.296	n.s.
Deflecting wrinkle	LM2	32	0	110	0	0.718	n.s.
Deflecting wrinkle	LM3	28	0	81	1	1.811	n.s.
Protostylid	LM1	34	3	113	0	3.346	n.s.
Protostylid	LM2	31	0	110	1	0.283	n.s.
Protostylid	LM3	27	4	81	2	3.669	n.s.
Hypoconulid	LM1	35	77	107	83	6.142	n.s.
Hypoconulid	LM2	32	38	108	19	20.551	<0.001
Hypoconulid	LM3	28	25	81	23	14.918	<0.001
Entoconulid	LM1	35	0	111	0	1.556	n.s.
Entoconulid	LM2	32	0	109	0	3.997	n.s.
Entoconulid	LM3	28	0	81	0	5.591	n.s.
Metaconulid	LM1	35	0	111	0	na	—
Metaconulid	LM2	32	0	108	0	na	—
Metaconulid	LM3	28	4	78	3	3.586	n.s.

[1] na, not applicable; n.s., not significant.
[2] Using Bonferroni's correction

Canada, Athapaskan, California, Eastern US/Canada, Gulf of Alaska, Hong Kong, Japan, Lake Baikal, NE Siberia, NW Canada/US, Southwest US; and in the Sundadont pattern: Burma, Early Malay, Early Mainland (SeA), Indomalaysia, Jomon, Nepal, Philippines, South China 1 and 2, South East Asia, Thai, Taiwan; and Europe was classified as a group alone.

Examining the dental variation observed in prehispanic Mexico within the Sinodont/Sundadont pattern, it is observed that the Mexican groups do not follow a strict Sinodont/Sundadont classification; 27% of the dental traits present frequencies consistent with the Sinodont variation, while 73% of the traits examined show incidence similar to those seen in Southeast Asian groups. The eight defining traits that distinguished the Sinodont/Sundadont classification (Turner, 1990) were used in this analysis. Cholula was the only population that was classified as Sinodont (Table 11b). When the discriminant function derived from Turner's Asiatic and American data is applied to the Mexican samples, it is found that these samples fit an overall Sundadont classification (Table 11b). Taking into account that three traits (3-root UM2, 1-root UP2, and 3-root LM1) in the Mexican groups had a very low sample size, the same analysis was performed excluding these traits. The result was very similar, although with higher percentages: 34% of the dental traits present frequencies consistent with the Sinodont variation, while 66% of the traits show similar incidence to Sundadont populations. Again, Cholula was the only population that was classified as Sinodont. In summary, these results indicate that among New World populations there are some populations that fit the Sundadont pattern, suggesting extensive dental morphological variation among American Indians.

DISCUSSION

The present paper is a comprehensive study describing the dental morphology of four skeletal prehispanic Mesoamerican populations. The prehispanic Mexican dentition is characterized by high frequencies of double shoveling on the maxillary incisors, enamel extension on the maxillary molars, "Y" groove pattern on the mandibular second molars and low frequencies of strong expression of shoveling on the maxillary incisors, peg, reduced maxillary third molars, and deflecting wrinkle on the lower mandibular molars.

There are differences in the incidence of dental morphological traits of the permanent dentition among the four Mesoamerican populations studied (Tlatilco, Cuicuilco, Monte Albán, and Cholula). Tlatilco is the oldest of these four prehispanic groups and exhibits the greatest number of significant differences in the frequencies of dental

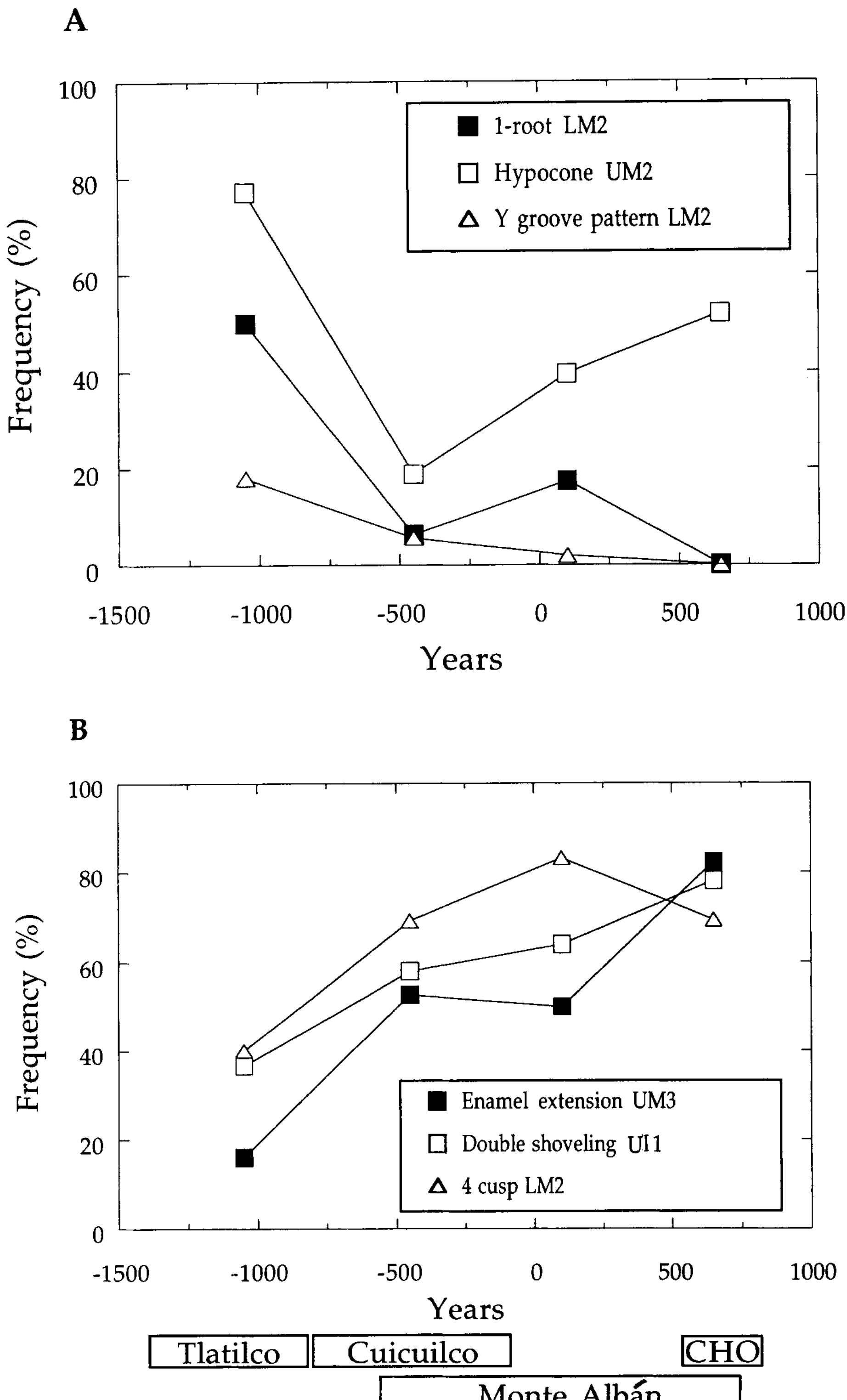

Fig. 2. Six examples of dental morphological traits according to population chronology. Dating is as follows: Tlatilco, 1300–800 BC; Cuicuilco, 800–100 BC; Monte Albán, 500 BC–700 AD; and Cholula, 550–750 AD. **A:** One-root LM2, Hypocone UM2, and "Y" groove pattern LM2. **B:** Enamel extension UM3, double shoveling UI1, and 4 cusp LM2. Negative numbers are BC; positive numbers are AD.

TABLE 9. Dental trait frequencies of New World populations

Trait[1]: Location:	Winging UI1		Shoveling UI1		Double shoveling UI1		Mesial ridge UC		Hypocone UM2		Cusp 5 UM1		Carabelli's cusp UM1	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Aleut-Eskimo[2]	51	29.1	115	79.3	68	52.3	—	—	243	75.9	49	17.9	43	14.8
Athapaskan[3]	—[5]	40.9	—	73.0	—	45.3	—	0.0	—	68.1	—	—	—	22.6
California[3]	—	42.6	—	97.7	—	89.9	—	2.2	—	92.9	—	—	—	44.9
Cholula[4]	19	**15.8**	22	**68.2**	23	**78.1**	27	**3.7**	25	**96.0**	25	**0.0**	25	**20.0**
Cuicuilco[4]	17	**11.8**	18	**50.1**	19	**58.0**	30	**3.3**	32	**87.6**	32	**0.0**	30	**3.3**
Eastern US/Canada[3]	—	48.7	—	91.3	—	78.3	—	1.6	—	93.2	—	—	—	33.8
Gulf of Alaska[3]	—	30.1	—	82.3	—	66.2	—	0.0	—	84.2	—	—	—	22.5
Indian[2]	292	46.3	743	91.2	512	71.3	—	—	279	87.9	178	17.6	372	33.2
Monte Albán[4]	20	**20.0**	26	**57.6**	25	**64.0**	44	**6.8**	48	**83.3**	55	**5.4**	55	**25.4**
Na-Dene[2]	47	35.9	73	82.9	48	54.5	—	—	279	86.4	66	24.8	68	24.5
NW Canada/US[3]	—	32.2	—	83.2	—	53.7	—	0.7	—	89.1	—	—	—	—
South American[3]	—	53.4	—	92.2	—	90.2	—	1.7	—	89.8	—	—	—	—
Southwest US[3]	—	43.1	—	90.8	—	63.0	—	1.7	—	82.5	—	—	—	—
Tlatilco[4]	28	**10.7**	31	**35.5**	30	**36.6**	32	**3.1**	35	**77.1**	34	**8.8**	34	**11.1**

Trait[1]: Location:	Parastyle UM3		3-root UM2		1-root UP1		Peg/ reduced/ congenital absence UM3		Entoconulid LM1	
	n	%	n	%	n	%	n	%	n	%
Aleut-Eskimo[2]	10	3.9	146	35.4	522	94.4	—	—	134	47.7
Athapaskan[3]	—	—	—	42.3	—	91.0	—	30.0	—	44.7
California[3]	—	—	—	67.7	—	83.9	—	16.6	—	39.9
Cholula[4]	18	**11.2**	4	**100.0**	10	**80.0**	26	**22.2**	34	**0.0**
Cuicuilco[4]	19	**0.0**	12	**100.0**	17	**94.1**	30	**16.7**	42	**0.0**
Eastern US/Canada[3]	—	—	—	67.1	—	80.1	—	17.9	—	49.9
Gulf of Alaska[3]	—	—	—	36.4	—	94.7	—	23.9	—	36.0
Indian[2]	32	4.5	564	58.3	1,077	85.3	—	—	544	54.0
Monte Albán[4]	20	**5.0**	24	**95.8**	19	**73.7**	41	**19.5**	61	**0.0**
Na-Dene[2]	8	3.4	192	45.9	500	92.6	—	—	115	49.8
NW Canada/US[3]	—	—	—	42.9	—	93.3	—	14.0	—	43.2
South American[3]	—	—	—	49.8	—	86.3	—	24.6	—	53.3
Southwest US[3]	—	—	—	54.0	—	89.4	—	20.6	—	45.0
Tlatilco[4]	28	**0.0**	3	**33.3**	6	**66.7**	32	**3.1**	48	**0.0**

Trait[1]: Location:	Protostylid LM1		Metaconulid LM1		3-root LM1	
	n	%	n	%	n	%
Aleut-Eskimo[2]	80	23.0	48	12.9	190	36.7
Athapaskan[3]	—	41.9	—	—	—	10.4
California[3]	—	39.6	—	—	—	8.2
Cholula[4]	35	**0.0**	9	**0.0**	9	**0.0**
Cuicuilco[4]	45	**0.0**	15	**0.0**	15	**0.0**
Eastern US/Canada[3]	—	41.2	—	—	—	6.1
Gulf of Alaska[3]	—	27.7	—	—	—	22.4
Indian[2]	589	45.0	108	9.8	108	6.7
Monte Albán[4]	62	**0.0**	24	**0.0**	24	**0.0**
Na-Dene[2]	109	34.8	83	7.0	83	15.0
NW Canada/US[3]	—	35.0	—	—	—	15.8
South American[3]	—	29.8	—	—	—	6.2
Southwest US[3]	—	52.7	—	—	—	6.2
Tlatilco[4]	47	**2.1**	5	**0.0**	5	**0.0**

[1] Scoring procedures and expression dichotomy are given in Table 2 (from Turner et al. [1991]).
[2] Data from Turner (1983).
[3] Data from Turner (1986).
[4] Data from original source.
[5] Dashes indicate data not available.

TABLE 10. List of Mongoloid populations and dental morphological traits used in the discriminant analysis

a. List of populations
- Amur[1]
- Archaic Canada[2]
- Athapaskan[2]
- Burma[1]
- California[2]
- **Cholula**[3]
- **Cuicuilco**[3]
- Early Malay[1]
- Early Mainland (SeA)[1]
- Eastern US/Canada[2]
- Europe[1]
- Gulf of Alaska[2]
- Hong Kong[1]
- Indomalaysia, recent[1]
- Japan, recent[1]
- Jomon[1]
- Lake Baikal[1]
- **Monte Albán**[3]
- Nepal[1]
- NE Siberia[1]
- NW Canada/US[2]
- Philippines[1]
- SeA, recent[1]
- South China 1 and 2[1]
- Southwest US[2]
- Taiwan, prehistoric[1]
- Thai, recent[1]
- **Tlatilco**[3]

b. List of predicting dental morphological traits
- Winging UI1
- Shoveling UI1[4]
- Double shoveling UI1[4]
- Mesial ridge UC
- Hypocone UM2
- Cusp 5 UM1
- Carabelli's cusp UM1
- Enamel extension UM1[4]
- 1-root UP2[4]
- 3-root UM2
- Peg/reduced/congenital absence UM3[4]
- Deflecting wrinkle LM1[4]
- Cusp 6 LM1
- Protostylid LM1
- 3-root LM1[4]
- Groove pattern LM2[4]

[1] Data from Turner (1987).
[2] Data from Turner (1986).
[3] Data from original source.
[4] Eight defining traits for the Sinodont/Sundadont division (Turner, 1990).

TABLE 11. Discriminant analysis of dental morphological traits between prehispanic Mexican Indian, modern New World, and Asian populations

a. Discriminant analysis using Turner's published dental frequencies for Sinodont and Sundadont populations: Percentage of correct discrimination among populations (n = 24).
Maximum classification achieved: 100%, with 13 discriminant dental traits.

Classification:		Predicted groups		
Actual group	n	1	2	3
Sinodont	(12)	12 (100%)	0	0
Sundadont	(11)	0	11 (100%)	0
Europe	(1)	0	0	1 (100%)

b. Classification of the Mexican samples using the function derived from Turner's data

	Predicted group allocation	
Population	Sundadont	Sinodont
Cholula	—	χ
Cuicuilco	χ	—
Monte Albán	χ	—
Tlatilco	χ	—

morphological traits. This heterogeneity can be explained by two different hypotheses. The first of these postulates that the population of Tlatilco has a different origin or results from a different migration within Mesoamerica than the other three groups studied. This hypothesis is in concordance with other authors (Bernal, 1968; Niederberger, 1976; Porter, 1953), who have suggested that the people of Tlatilco received a great influence from the Olmec culture (the oldest civilization of Mesoamerica) and that some Olmec people could have migrated to Tlatilco. The second hypothesis suggests that genetic drift could account for the dental variation observed. Therefore, there may be a biological continuity from Tlatilco to Cuicuilco, Monte Albán, and Cholula. There are 22 dental traits (24.7%) that show a temporal cline from Tlatilco to the other Mesoamerican populations that would support such a view.

An interesting point of the distance matrix between the Mexican populations is that the groupings correspond somewhat to geographical distances between samples. For example, Tlatilco, although being the most divergent group, is closer to Cuicuilco than to Cholula and Monte Albán (Fig. 1). Tlatilco is approximately 17 kilometers apart from Cuicuilco, and the two are geographically more proximal to each other than any of the other populations. Cuicuilco and Cholula, the least divergent populations, are the samples geographically next most proximal to each other.

There are many untested assumptions regarding the true biological and cultural relationships of prehispanic Mesoamerican populations, their archaeological evidence, and microevolution (Culbert, 1978; Porter, 1993).

Further research needs to be carried out regarding these assumptions.

In a regional perspective, when the prehispanic Mesoamerican populations are compared to other New World populations (Turner, 1983, 1986a), their dentition does not follow a strict Sinodont/Sundadont classification. That is, the Mexican populations have more dental characters with frequencies similar to Sundadonts than Sinodonts, and overall they fit the Sundadont pattern described by Turner. Relative to other populations of American Indians (Dahlberg, 1949; Hrdlicka, 1931; Scott et al., 1983; Turner, 1991), the Mesoamerican groups in this study have a low frequency of the almost universal trait for the Sinodont pattern, shoveling of upper incisors. This low frequency is also found in the Inuit of the Central Arctic (Mayhall, 1979). The present study indicates that, while most Mexican Indians have shovel-shaped incisors, the stronger expressions are not as common as in other American Indian groups.

Previous studies have shown that American Indian populations follow the Sinodont pattern (Scott et al., 1983; Turner, 1983, 1985a, 1986a). The results of the discriminant analysis performed indicate that certain New World populations show frequencies of dental traits most consistent with the Sundadont pattern, suggesting extensive dental morphological variation among American Indians. Similar conclusions were reached by other researchers, who found differences in cranial morphology between Paleo-Indians and North Asian populations (Neves and Pucciarelli, 1991; Powell, 1993; Steele and Powell, 1992). Furthermore, the cranial differences between Paleo-Indians and North Asians are also observed in remains from Tierra del Fuego/Patagonia (Lahr, 1995). The results obtained in this study show that although Sinodonty and Sundadonty may be identified at the level of each population and overall dental frequencies, its expression in each of the 28 traits used is very variable and complex. This supports the conclusions of other researchers, who have suggested that Paleo-Indians are biologically distinct from Northeast Asians (Powell, 1993) and have found dental heterogeneity among middle Holocene native Americans (Powell, 1995) Similarly, the successful multivariate discrimination between Sundadonts and Sinodonts obtained in this study was based on 13 traits, only 4 of which showed a relevant correlation with the function. These four traits are recognized as derived for Sinodonts. In many of the other dental traits used, the frequencies can vary markedly between populations.

Establishing the presence of Sundadont dental characteristics among the prehispanic Mesoamerican populations raises a number of evolutionary questions. Given the Sundadont character of some Paleo-Indian dental traits (Powell, 1995), it is possible that the first population to have entered the continent was closer to present Southeast Asians in dental morphology than to North Asian groups and that such features were still expressed in prehispanic Mesoamericans. However, many untested assumptions like environmental factors, gene flow, and natural selection need to be examined. It is clear that the number, form, timing, route, and origin of early migrants into the New World are still controversial issues in human evolution. The basic issue underlying this debate is the pattern of American Indian diversity. Further research needs to be carried out on the biological and cultural significant differences observed among American Indians.

CONCLUSIONS

This study describes and compares the dental morphology of four prehispanic Mesoamerican populations.

Two main conclusions are derived from this work:

1. Tlatilco, the oldest of the populations studied, exhibits a different dental morphology from the other Mesoamerican populations.
2. The prehispanic Mesoamerican populations follow the Sundadont dental pattern, suggesting that there is extensive dental variation among American Indian populations.

ACKNOWLEDGMENTS

I thank the editor of the AJPA and two reviewers for their constructive and helpful comments on this manuscript. I am deeply grateful to Professor C.G. Turner II for allowing me to use his data. I thank the following people for their permission to study skeletal material under their care: L. Márquez and J.C. Jiménez, National Museum of Anthropology and History, Mexico; R.A. Foley, Duckworth Collection, Cambridge; and R. Kruszynski and C. Stringer, Natural History Museum, London. Many thanks to B. Arensburg, R.A. Foley, M.M. Lahr, and B. Podbilewicz for critically reading the manuscript. Special thanks to R.A. Foley for introducing me to the world of anthropology, M.M. Lahr for constructive discussions throughout this work, and C.G.N. Mascie-Taylor and M.D. Leney for statistical advice. This research was supported by a fellowship from the National Council of Science and Technology (CONACYT), Mexico, and Overseas Research Student Award (O.R.S.), UK, and a travel award from Downing College and the Department of Biological Anthropology, Cambridge.

LITERATURE CITED

Anderson JE (1965) Human skeletons of Tehuacan. Science *148:*496–497.

Baume R, and Crawford MH (1978) Discrete dental trait in four Tlaxcaltecan Mexican populations. Am. J. Phys. Anthropol. *49:*351–360.

Baume R, and Crawford MH (1980) Discrete dental trait asymetry and Mexican and Belizean groups. Am. J. Phys. Anthropol. *52:*351–361.

Bernal I (1968) El Mundo Olmeca. México: Editorial Porrúa.

Berry AC, and Berry RJ (1967) Epigenetic variation in the human cranium. J. Anat. *101:*361–379.

Birdsell JB (1972) Human Evolution. Chicago: Rand McNally.

Blanton RE, Kowalewski SA, Feinman G, and Appel J (1993) Ancient Mesoamerica. A Comparison of Change in Three Regions. Cambridge, UK. Cambridge University Press.

Brewer-Carias CS, LeBlanc S, and Neel JV (1976) Genetic structure of a tribal population, the Yanomama Indians. XIII. Dental micro-differentiation. Am. J. Phys. Anthropol. *44:*5–14.

Byers DS (1967) The Prehistory of the Tehuacan Valley. Austin: University of Texas Press.

Campbell BG (1971) Human Evolution: An Introduction to Man's Adaptations. Chicago: Aldine.

Comas J (1960) Manual of Physical Anthropology. Springfield IL: Charles C. Thomas.

Coon CS (1962) The Origin of Races. New York: A.A. Knopf.

Crawford MH (1992) Antropología Biológica de los Indios Americanos. Madrid: Editorial MAPFRE, S.A.

Culbert TP (1978) Mesoamerica. In JD Fennings (ed.): Ancient North Americans. San Francisco: W.H. Freeman and Company, pp. 495–555.

Dahlberg AA (1949) The dentition of the American Indian. In WS Laughlin (ed.): Papers on the Physical Anthropology of the American Indian. New York: Viking Fund, Inc., pp. 138–177.

Dahlberg AA (1963) Dental evolution and culture. Hum. Biol. *35:*237–249.

Dikov NN (1978) Ancestors of Paleo-Indians and Proto-Eskimos-Aleuts in the Paleolithic of Kamchatka. In AL Bryan (ed.): Early Man in America from a Circum-Pacific Perspective. Edmonton, Alberta: Archeological Researches International, pp. 68–69.

Fitzhugh WW, and Chaussonnet V (1988) Anthropology of the North Pacific rim. Washington: Smithsonian Institution Press.

Green RF, and Suchey JM (1976) The use of inverse sine transformations in the analysis of non-metric cranial data. Am. J. Phys. Anthropol *45:*61–68.

Greenberg JH, Turner GC II, and Zegura SL (1986) The settlement of the Americas: A comparison of the linguistic, dental, and genetic evidence. Curr. Anthropol. 27:477–497.

Guthrie RD (1990) Frozen Fauna of the Mammoth Steppe. The Story of Blue Babe. Chicago: University of Chicago Press.

Heyden D and Gendrop P (1988) Pre-Columbian Architecture of Mesoamerica. London: Faber and Faber Limited.

Hopkins D, Matthews J, Schwegger C, and Young S (1982) Paleoecology of Beringia. New York: Academic Press.

Howells WW (1989) Skull Shapes and the Map. Craniometric Analysis in the Dispersion of Modern Homo. Cambridge, MA: Harvard University.

Hrdlička A (1931) Anthropology of the Sioux. Am. J. Phys. Anthropol. *16:*123–166.

Hrdlička A (1937) Early man in America: What have the bones to say? In CG MacCurdy (ed.): Early Man as Depicted by Leading Authorities at the International Symposium at the Academy of Natural Sciences. Philadelphia: J.B. Lippincott, pp. 93–104.

Jorgensen KD (1955) The dryopithecus pattern in recent Danes and Dutchmen. J. Dent. Res. *34:*195–208.

Kirchhoff P (1952) Meso-America: Its geographic limits, ethnic composition and cultural characteristics. In S Tax (ed.): Heritage of Conquest. Chicago, Illinois: The Free Press Publishers, pp 17–30.

Lahr MM (1995) Patterns of modern human diversification: Implications for Amerindian origins. Yrbk. Phys. Anthropol. *38:*163–198.

Laughlin WS (1988) From Ammassalik to Attu: 10,000 years of divergent evolution. Objets et Mondes *25:* 141–148.

Mayhall JT (1979) The dental morphology of the Inuit of the Canadian central Arctic. OSSA *6:*199–218.

Miller RG (1981) Simultaneous Statistical Inference. New York: Springer-Verlag.

Moorrees CFA (1957) The Aleut Dentition. Cambridge: Harvard University Press.

Moorrees CFA (1962) Genetic considerations in dental anthropology. In CJ Witkop (ed.): Genetics and Dental Health. New York: McGraw Hill, pp. 101–112.

Neel JV, and Thompson EA (1978) Founder effect and the number of private polymorphisms observed in Amerindian tribes. Proc. Natl. Acad. Sci. U.S.A. *75:*1094–1098.

Neumann GK (1952) Archeology and race in the American Indians. In JB Griffin (ed.): Archeology of Eastern United States. Chicago: University of Chicago Press.

Neves WA, and Pucciarelli HM (1991) Morphological affinities of the first Americans: An exploratory analysis based on early South American human remains. J. Hum. Evol. *21:*261–273.

Nichol CR, and Turner CG II (1986) Intra- and inter-observer concordance in observing dental morphology. Am. J. Phys. Anthropol. *63:*361–370.

Nicholson HB (1978) Western Mesoamerica: A.D. 900–1520. In RE Taylor and CW Meigham (eds.): Chronologies in New World Archaeology. New York: Academic Press, pp. 285–327.

Niederberger C (1976) Zohapilco. Cinco Milenios de Ocupación Humana en un Sitio Lacustre de la Cuenca de México. México: Instituto Nacional de Antropología e Historia.

Palomino H, Chakraborty R, and Rothhammer F (1977) Dental morphology and population diversity. Hum. Biol. *49:*61–70.

Pedersen PO (1949) The East Greenland Eskimo Dentition. Meddel. om Grønland *142:*1–256.

Piña CR (1972) Historia Arqueología y Arte Prehispánico. México: Fondo de Cultura Económica.

Pompa JA (1990) Antropología Dental, Aplicación en Poblaciones Prehispánicas. México: Instituto Nacional de Antropología e Historia.

Porter MW (1953) Tlatilco and the pre-classic cultures of the New World. Viking Fund, Publications in Anthropology *19:*5–101.

Porter MW (1993) The Aztecs, Maya, and their Predecessors. Archaeology of Mesoamerica. U.S.A.: San Diego, CA: Academic Press.

Powell JF (1993) Dental evidence for the peopling of the New World: Some methodological considerations. Hum. Biol. *65:*799–819.

Powell JF (1995) Dental variation and biological affinity among Middle Holocene human populations in North America. PhD thesis, Texas A & M University, College Station, USA.

Schanfield MS (1992) Immunoglobulin allotypes (GM and KM) indicate multiple founding populations of native Americans: Evidence of at least four migrations to the New World. Hum. Biol. *64:*381–402.

Sciulli PW (1990) Deciduous dentition of a late archaic population of Ohio. Hum. Biol. *62:*221–245.

Scott GR, and Turner CG II (1988) Dental anthropology. Annual Review of Anthropology *17:*99–126.

Scott GR, Potter RHY, Noss JN, Dahlberg AA, and Dahlberg T (1983) The dental morphology of Pima Indians. Am. J. Phys. Anthropol. *61:*13–31.

Semo E (1981) México Prehispánico: Origen y Formación de las Clases Sociales. México: Universidad Autónoma de Puebla.

Steele DG, and Powell JF (1992) The peopling of the Americas: Paleobiological evidence. Hum. Biol. *64:* 303–336.

Stewart TD (1970) Physical Anthropology. Handbook of Middle American Indians, Vol. 9. Austin: University of Texas Press.

Stewart TD (1973) The People of America. New York: Charles Scribner's Sons.

Stewart TD, and Newman MT (1951) An historical résumé of the concept of differences in Indian types. Am. Anthropol. *53:*19–36.

Szathmary EJE (1984) Peopling of northern North America: Clues from genetic studies. Acta Anthropol. *8:*79–109.

Szathmary EJE, and Ossenberg NS (1978) Are the biological differences between North American Indians and Eskimos truly profound? Curr. Anthropol. *19:*694–701.

Tolstoy P (1978) Western Mesoamerica before A.D. 900. In RE Taylor and CW Meigham (eds.): Chronologies in New World Archaeology. New York: Academic Press, pp. 241–283.

Turner CG II (1969) Microevolutionary interpretations from the dentition. Am. J. Phys. Anthropol. *30:*421–426.

Turner CG II (1971) Three-rooted mandibular first permanent molars and the question of American Indian origins. Am. J. Phys. Anthropol. *34:*229–241.

Turner CG II (1979) Dental anthropological indications of agriculture among the Jomon people of central Japan. X. Peopling of the Pacific. Am. J. Phys. Anthropol. *51:*619–636.

Turner CG II (1983) Dental evidence for the peopling of the Americas. In R. Shutler (ed.): Early Man in the New World. Beverly Hills, CA: Sage Publications, pp. 147–157.

Turner CG II (1985a) Dental evidence for the peopling of the Americas. Natl. Geogr. Soc. Res. Reports *19:* 573–596.

Turner CG II (1985b) The dental search for Native American origins. In R Kirk and EJE Szathmary (eds.): Out of Asia. Canberra, Australia: Journal of Pacific History, Inc, pp. 31–78.

Turner CG II (1986a) The first Americans: The dental evidence. Natl. Geog. Res. *2:*37–46.

Turner CG II (1986b) Dentochronological separation estimates for Pacific rim populations. Science *232:* 1140–1142.

Turner CG II (1987) Late Pleistocene and Holocene population history of East Asia based on dental variation. Am. J. Phys. Anthropol. *73:*305–321.

Turner CG II (1990) The major features of Sundadonty and Sindodonty, including suggestions about East Asian microevolution, population history, and late Pleistocene relationships with Australian aboriginals. Am. J. Phys. Anthropol. *82:*295–317.

Turner CG II (1991) Dental Genetics and Microevolution in Prehistoric and Living Koniag Eskimos. New York and London: Garland Publications.

Turner CG II (1993) Southwest Indians: Prehistory through dentition. Natl. Geog. Res. Expl. *9:*32–53.

Turner CG II, and Scott GR (1977) Dentition of the Easter islanders. In AA Dahlberg and TM Graber (eds.): Orofacial Growth and Development. The Hague: Mouton, pp. 229–249.

Turner CG II, Nichol CR, and Scott GR (1991) Scoring procedures for key morphological traits of the perma-

nent dentition: The Arizona State University dental anthropology system. In MA Kelley and CS Larsen (eds.): Advances in Dental Anthropology. New York: Wiley-Liss, pp. 13–31.

Wallace DC, and Torroni A (1992) American Indian prehistory as written in the mitochondrial DNA: A review. Hum. Biol. *64*:403–416.

West FH (1981) The Archaeology of Beringia. New York: Columbia University Press.

Winter M (1989) Oaxaca: The Archaeological Record. México: Minutiae Mexicana.

APPENDIX Analysis of interobserver concordance

Trait/tooth Session rh-cgt[1]	n pairs	>1 grade variant scoring (%)	Mean grade difference Net (%)	*t* test (%)
Winging UI1	9	11.1[2]	11.1	0.43
Shoveling UI1	11	0.0	18.2	1.00
Shoveling UI2	21	9.5	28.6	2.03
Shoveling UC	26	3.8	−30.8	−2.86[2]
Double shoveling UI1	12	0.0	25.0	1.91
Double shoveling UI2	22	13.6[2]	13.6	0.77
Double shoveling UC	25	4.0	4.0	0.27
Double shoveling UP1	47	27.6[2]	−72.0[2]	−5.36[2]
Interruption groove UI1	9	[3]	66.7[2]	1.51
Interruption groove UI2	22	[3]	181.8[2]	5.68[2]
Tuberculum dentale UI1	10	20.0[2]	−70.0[2]	−1.91
Tuberculum dentale UI2	20	40.0[2]	50.0[2]	1.21
Tuberculum dentale UC	28	10.7[2]	−32.1	−2.08[2]
Distal accessory ridge UC	14	35.7[2]	−50.2[2]	−1.24
Accessory cusps UP1	52	[3]	−15.0[2]	−3.05[2]
Accessory cusps UP2	43	[3]	−7.0	−1.77
Metacone UM1	119	0.0	−3.8	−1.82
Metacone UM2	100	0.0	3.5	1.71
Hypocone UM1	114	0.0	3.5	2.03[2]
Hypocone UM2	92	0.0	6.0	2.76[2]
Cusp 5 (metaconule) UM1	68	8.8	0.0	0.0
Cusp 5 (metaconule) UM2	61	0.0	1.6	0.33
Carabelli's trait UM1	87	3.4	−23.0	−2.67[2]
Carabelli's trait UM2	85	2.3	0.0	0.0
Parastyle UM2	101	1.0	1.98	1.0
Odontome UP1	32	[3]	0.0	[2]
Odontome UP2	38	[3]	−2.6	−1.00
Enamel extension UM1	92	6.5	17.4[2]	2.42[2]
Enamel extension UM2	79	5.1	16.5[2]	1.93
Lingual cusp number LP1	21	19.0[2]	100.0[2]	1.95
Lingual cusp number LP2	21	23.8[2]	−9.5	−0.22
Groove pattern LM1	15	40.0[2]	−86.7[2]	−3.39[2]
Groove pattern LM2	30	13.3[2]	−83.3[2]	−7.05[2]
Cusp number LM1	21	0.0	−24.0[2]	−2.02
Cusp number LM2	27	3.7	−29.6[2]	−2.53[2]
Deflecting wrinkle LM1	22	0.0	13.6	1.82
Deflecting wrinkle LM2	14	0.0	28.6[2]	2.28[2]
Protostylid LM1	30	0.0	−13.3	−2.11[2]
Protostylid LM2	29	0.0	−6.9	−1.44
Cusp 5 (hypoconulid) LM1	9	11.1[2]	33.3	−1.41[2]
Cusp 5 (hypoconulid) LM2	14	28.6[2]	−85.7	−2.20
Cusp 6 (entoconulid) LM1	15	6.7	−20.0	−1.38
Cusp 6 (entoconulid) LM2	17	5.9	−17.6	−1.00
Enamel extension LM1	28	7.1	17.9[2]	1.31
Enamel extension LM2	28	7.1	−10.7	1.29
Odontome LP1	10	[3]	0.0	[3]
Odontome LP2	10	[3]	0.0	[3]

[1] Session: rh = RH's session; cgt = CGT's session.
[2] Exceeds critical value.
[3] Value not calculable.